



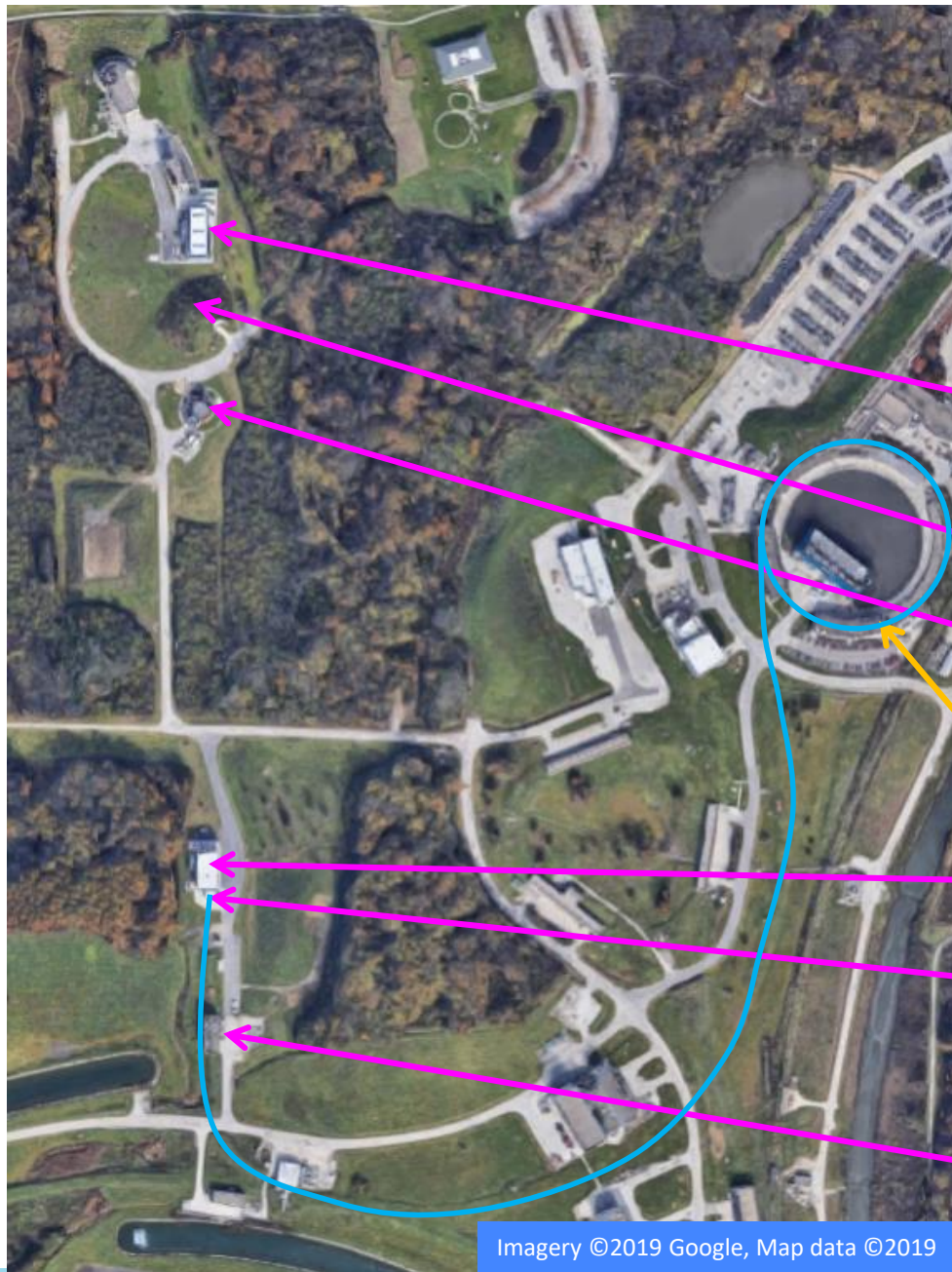
Booster Neutrino Beamline Status

Thomas R. Kobilarcik

Neutrino Beams and Instrumentation, 2019

22 October 2019

Booster Neutrino Beamline and Detectors



ICARUS (new)

MiniBooNE (off)

MicroBooNE (new)

Booster

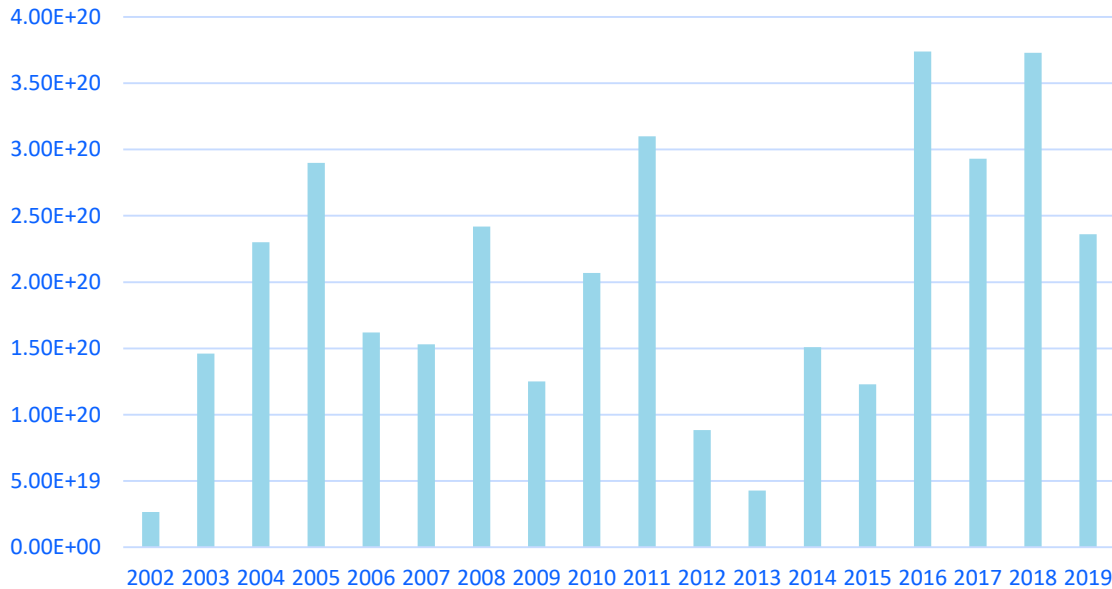
SB-ND (new)

ANNIE (new-ish)

Booster Neutrino Beamline
Target Hall

Imagery ©2019 Google, Map data ©2019

Annual Protons on Target



Since turning on, BNB has transported $3.6\text{E}21$ protons

The horns have pulsed $\sim 3/4$ of a billion times

BNB is assessed for 5×10^{12} protons per pulse at 5 Hz average

Off-target running (limited intensity)

- The “big news” – Horn #2 failed
 - Alignment module also failed and had to be redesigned
 - Took advantage of time to inspect decay pipe
- Then Horn #3 developed a problem (fixed in place)
 - Upgraded target hall profile monitors
- Prior to Horn #2 failure:
 - Ran in “off target mode” for dark matter search
 - Installed temporary profile monitors at 25 m absorber (to measure beam trajectory)
- Since Horn #3 installation:
 - Installed rapid trim to facilitate off-target running if requested
 - Measured bunch length before and after bunch rotation
 - Upgraded accelerator signal distribution system to better serve broadened Short Baseline program

Horn #2 Failed



Horn is buried in target pile

Part of beamline is removed to allow for working space.

Horn is transferred directly into coffin, reducing exposure



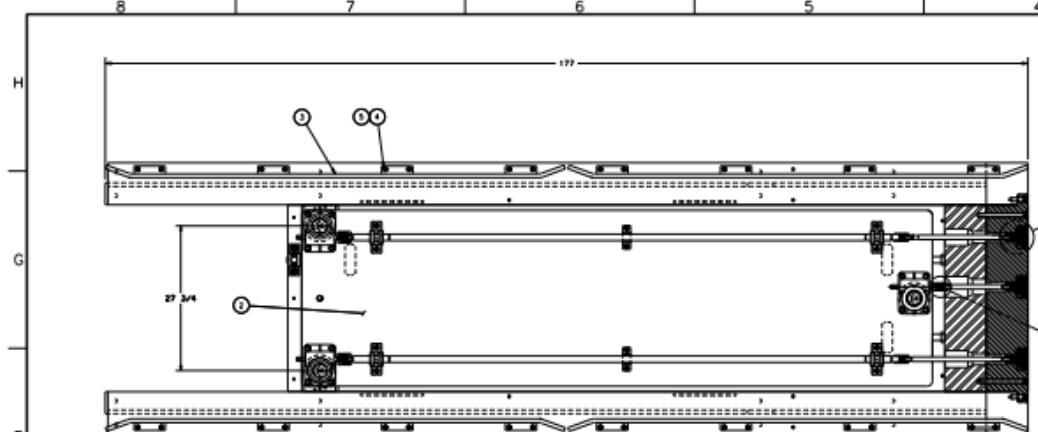
Second Horn Trivia

- December 2004 to 2015.
- 1/2 billion pulses.
- Two of the six water lines had been valved out due to leakage, but still had adequate cooling.
- Provided new data regarding fatigue of aluminum.
- Water is continually circulated, even during shutdowns and off-target running, to avoid stagnation.

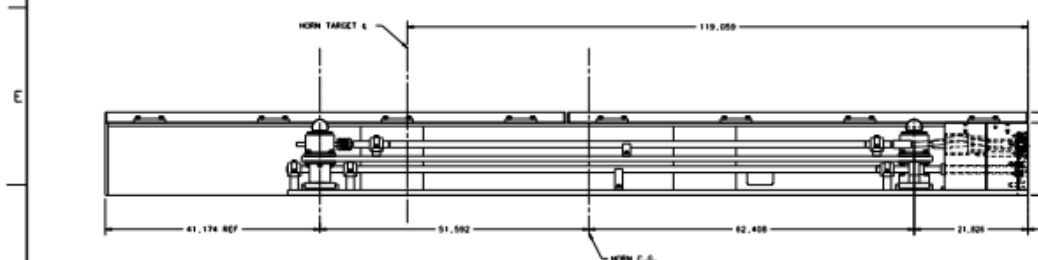
Target and Horn Assembly



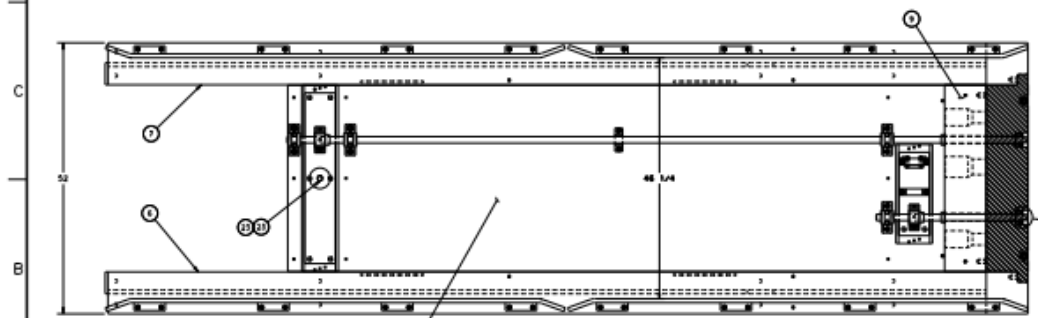
Target/Horn Assembly sits on an alignment module in the target pile
When we attempted to remove horn, found that alignment module no longer worked –
needed a new alignment module



SECTION A-A
(SECTION ONLY THROUGH ITEM #6 & #9)



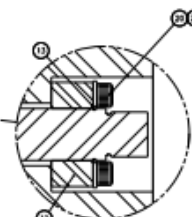
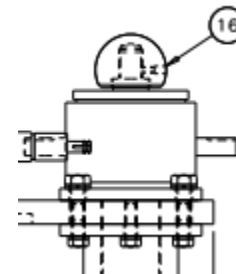
ITEM #6 REMOVED FROM THIS VIEW



SECTION B-B
(SECTION ONLY THROUGH ITEM #6)

Old alignment module used commercial screw jacks.

After 15 years, parts corroded, grease hardened, nothing worked.

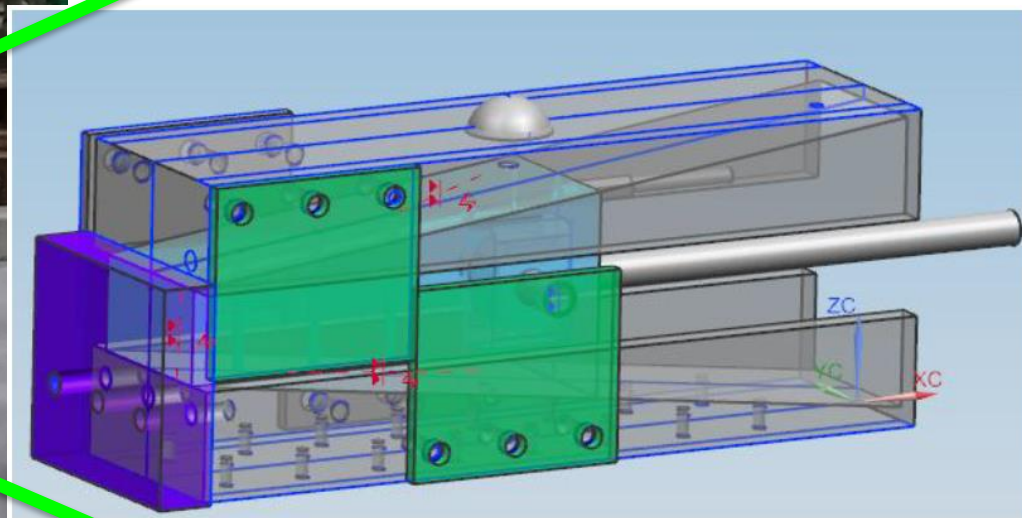


ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
16		ELL-107 FLEXIBLE SHMIT 21 TUB LG	2
15		ELL-107 FLEXIBLE SHMIT 14 5/16 LG	1
14	AM-389513	SHMIT REDUCER	1
13		1 1/4" S.S. EXTERNAL RETAINING RING	2
12	MC-389512	SHMIT RETAINING BLOCK	2
11	MC-389508	SHMIT RETAINER ASSEMBLY	3
10		5/32 S.S. SLOTTED SPRING PIN	6
9	MC-389431	REAR SHIELDING ADJUSTMENT BLOCK	1
8	MC-389270	FRONT SHIELDING ADJUSTMENT BLOCK	1
7	MC-389282	MAIN SUPPORT, RH	1
6	MC-389284	MAIN SUPPORT, LH	1
5		1/2 SS LOCK WASHER	32
4		1/2-13 UNC R 1 1/2 LG SS NUTS	32
3	MC-389269	SHIELD RAIL	4
2	MC-389270	JACK MOUNTING PLATE ASSEMBLY	1
1	MC-389260	BASIC PLATE ASSEMBLY	1

New Alignment Module

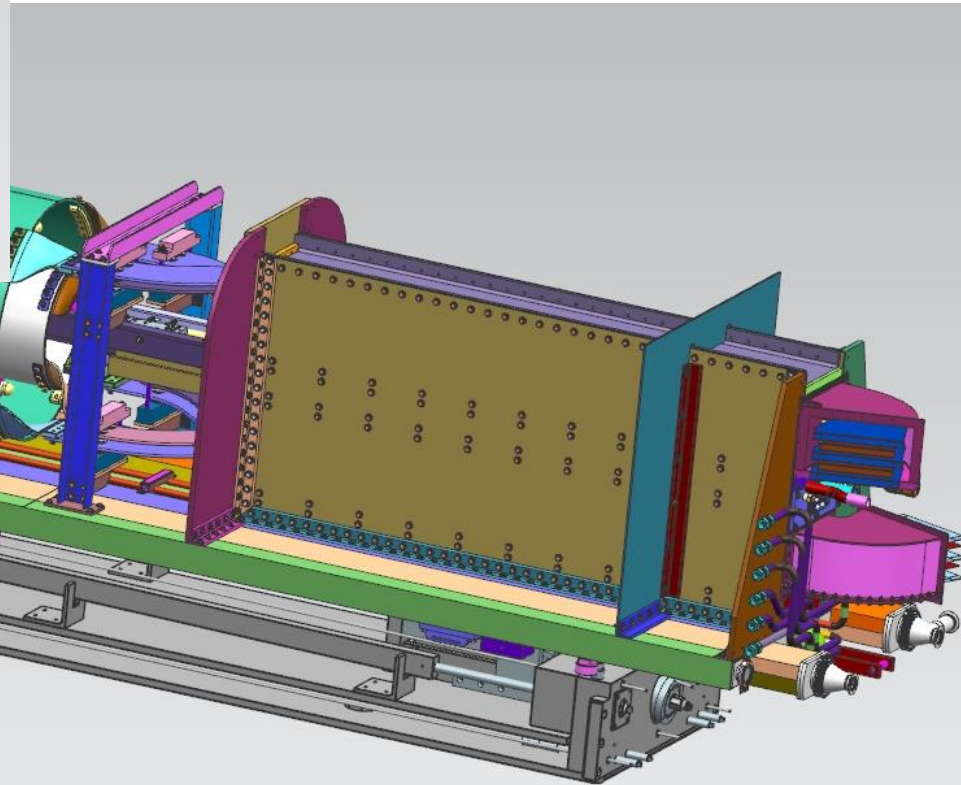
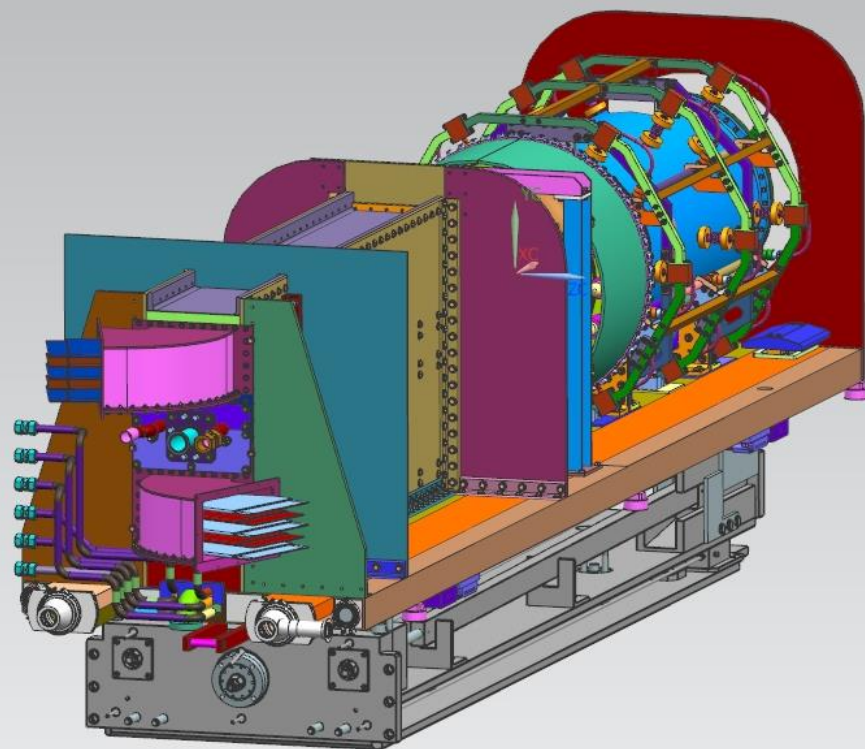
Brackets to hold push rod

Moving parts are anodized
and have provision for air
bearing



Lifting Wedge

Design by D. Pushka,
AD/Target Systems

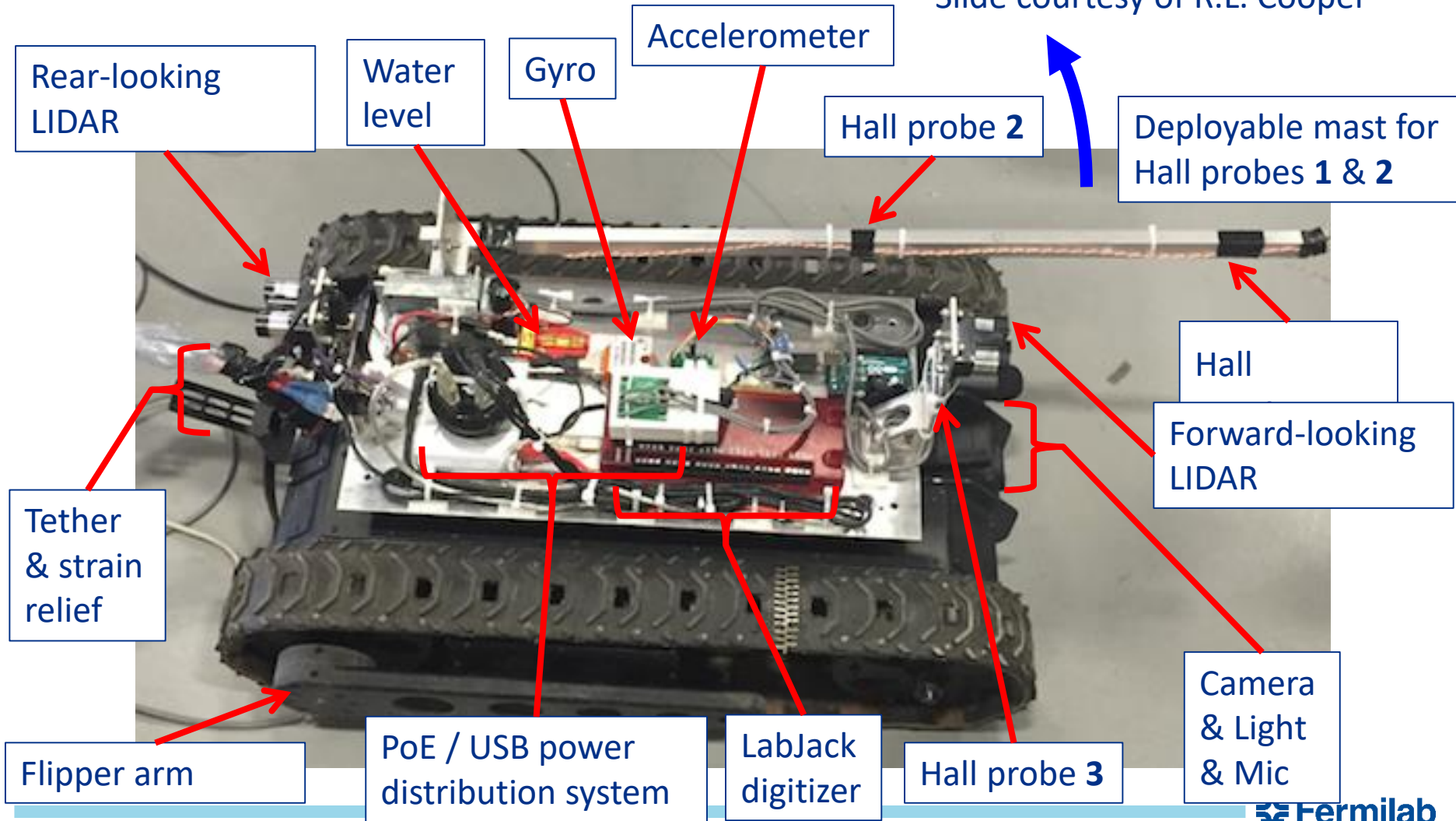


While the new alignment module was being designed ...

FRED*: Instrumentation Package

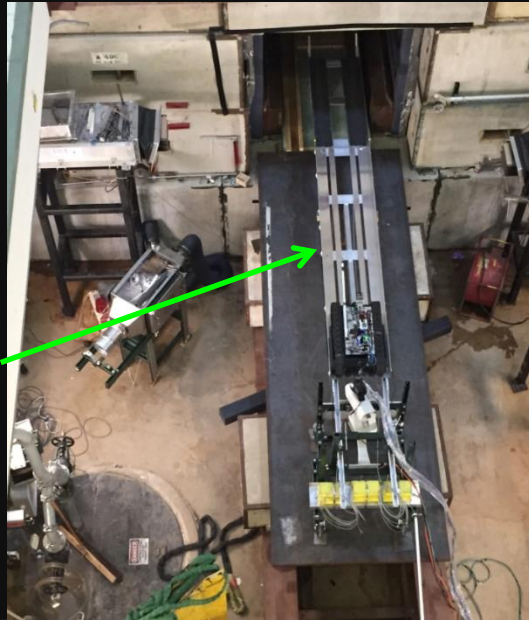
*Finding Radiation Evidence in the Decay pipe

Slide courtesy of R.L. Cooper



Boldly go where no one has gone...

FRED ready
to go into the
horn chase



Deployment Ladder



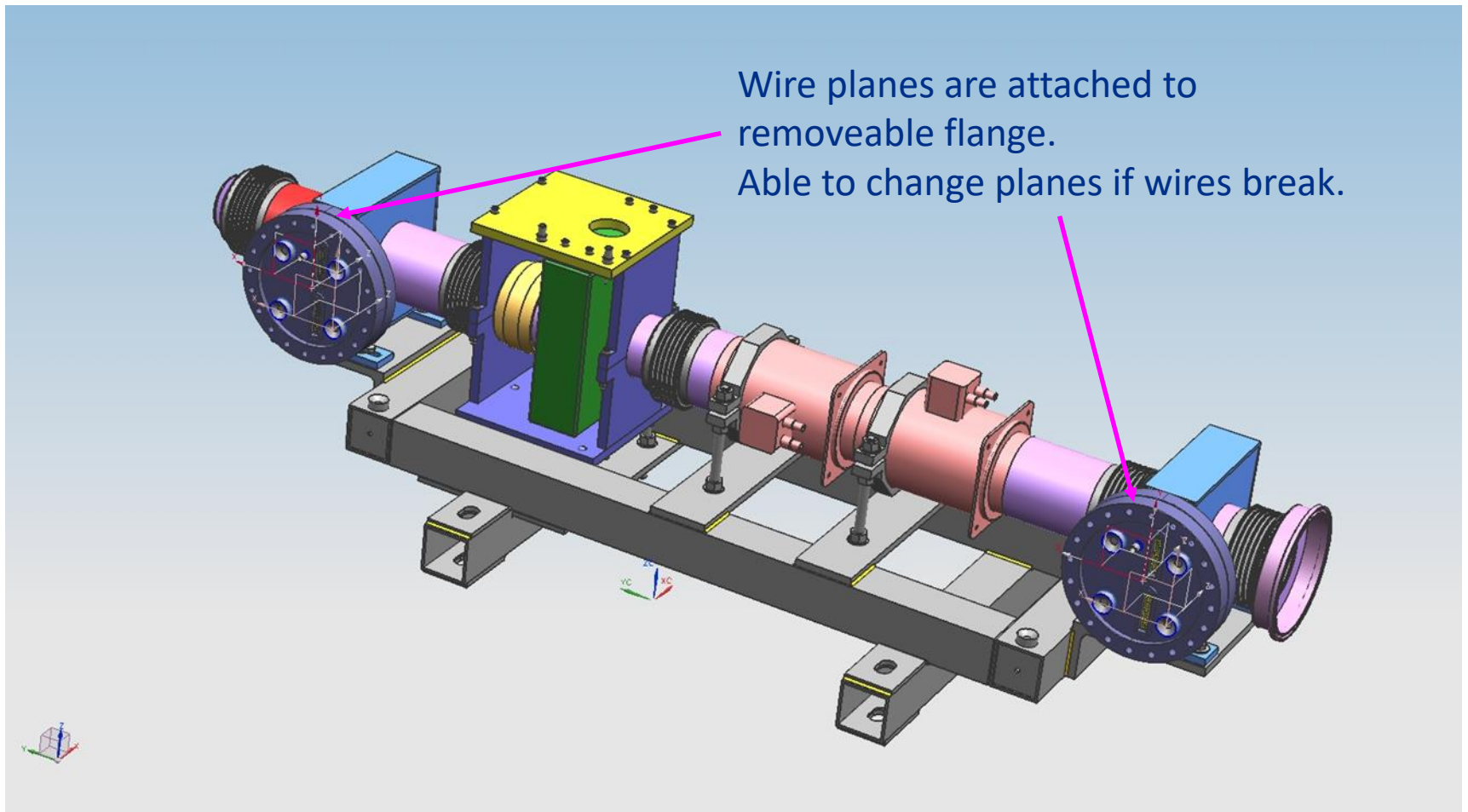
FRED in the collimator



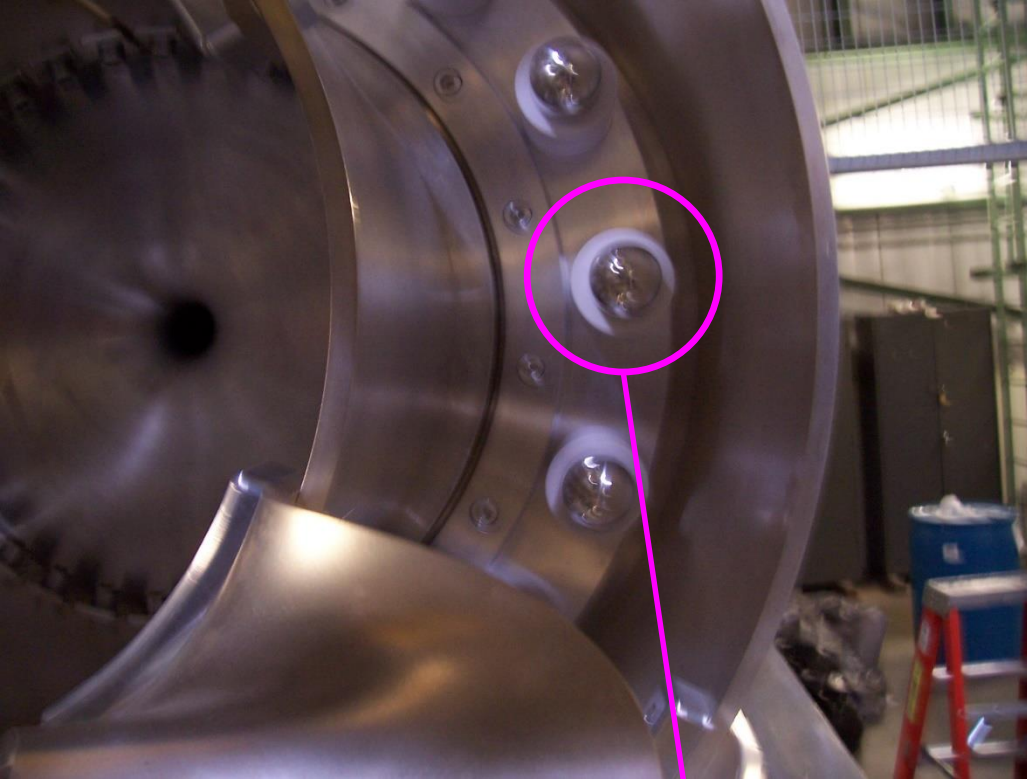
FRED climbing
the 25m step



FRED at the 50m
absorber, what the
heck is that...



Second generation low-mass multiwires. Welded joints, easy access to wire plane, more robust mechanical design. Separation between planes remains at 110 cm and planes retain 0.5 mm pitch. New instrumentation package was installed during Spring, 2015, horn change.

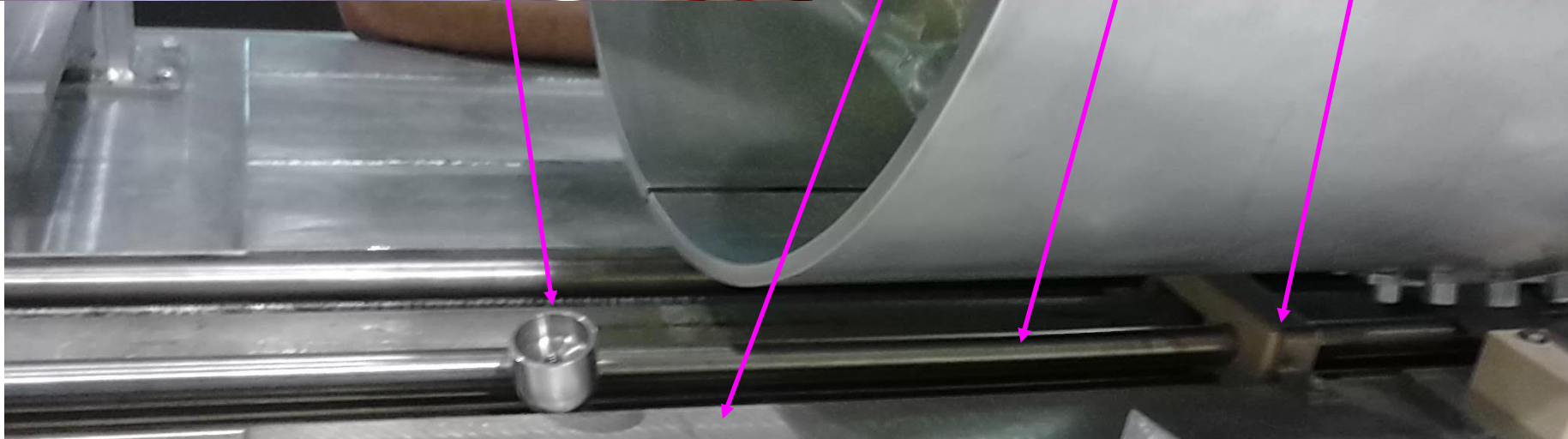


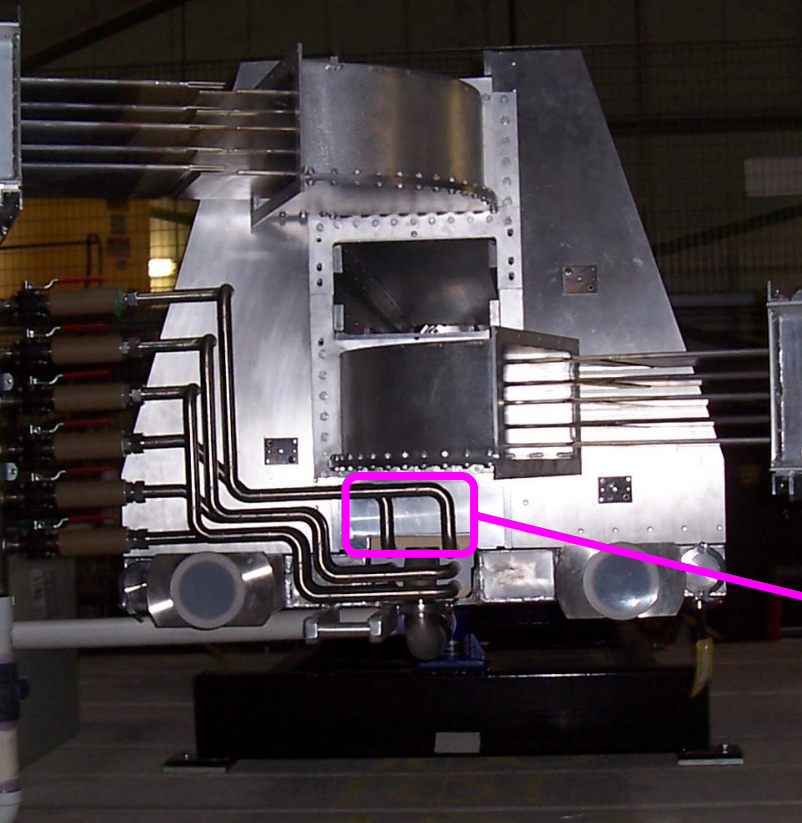
About a month into running, horn shorted to ground. This was caused by a corona cap that came loose and fell off. (Cap reduces corona cause by screw threads.)

Horn box
(ground)

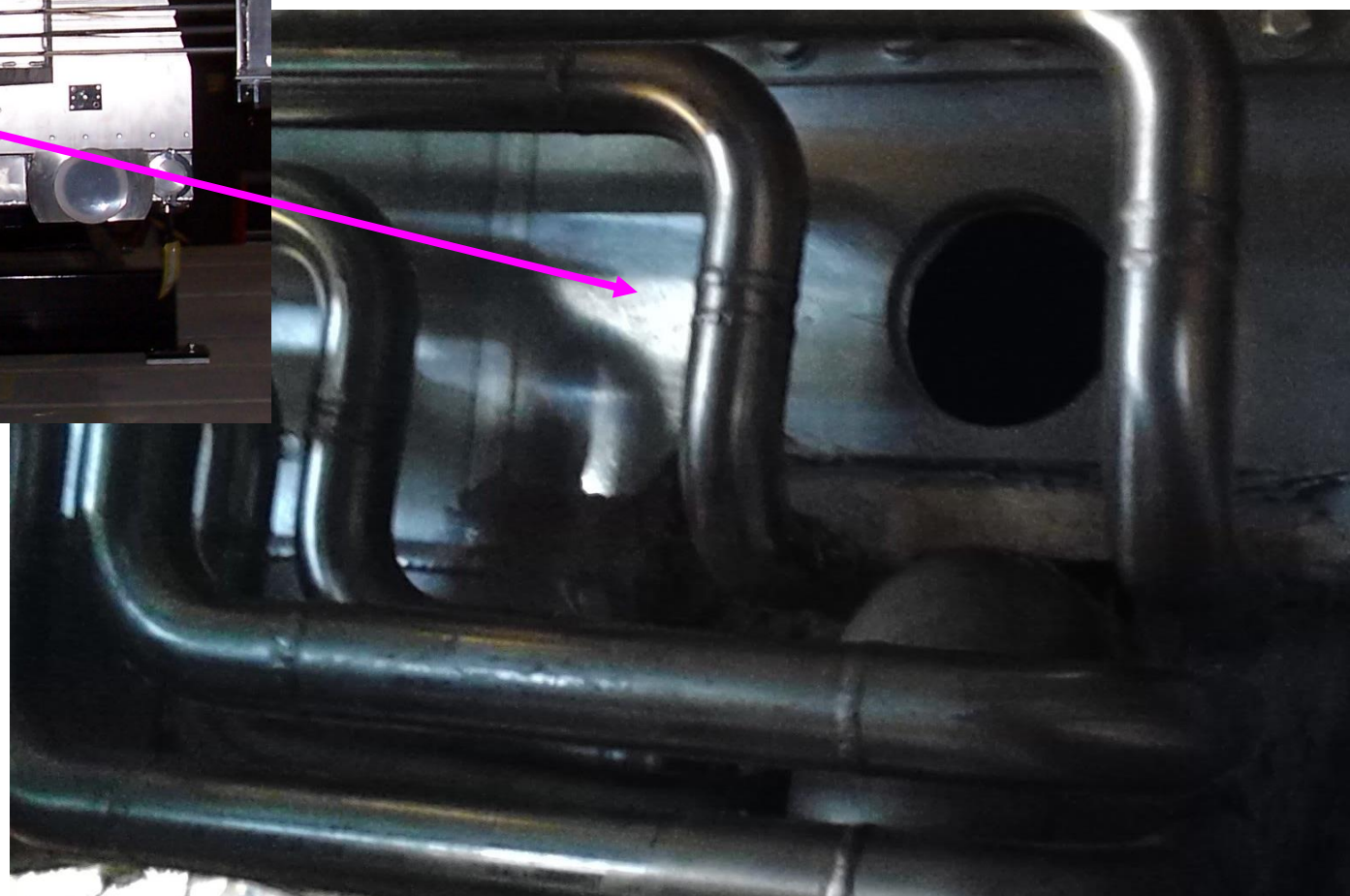
water drain line
(at voltage)

ceramic insulator





Hole in horn box through which the corona cap was removed.



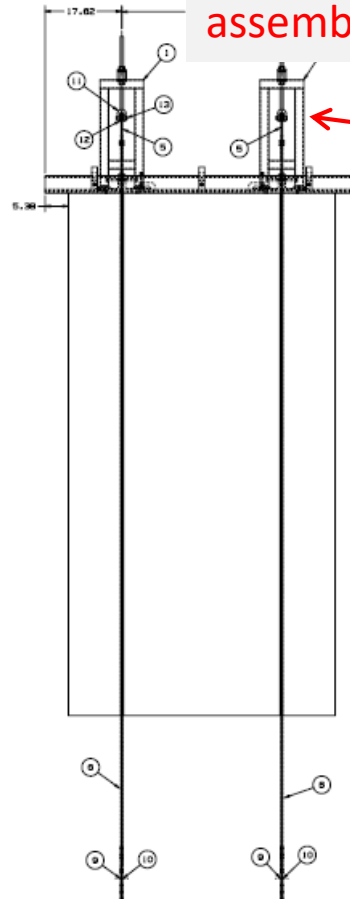
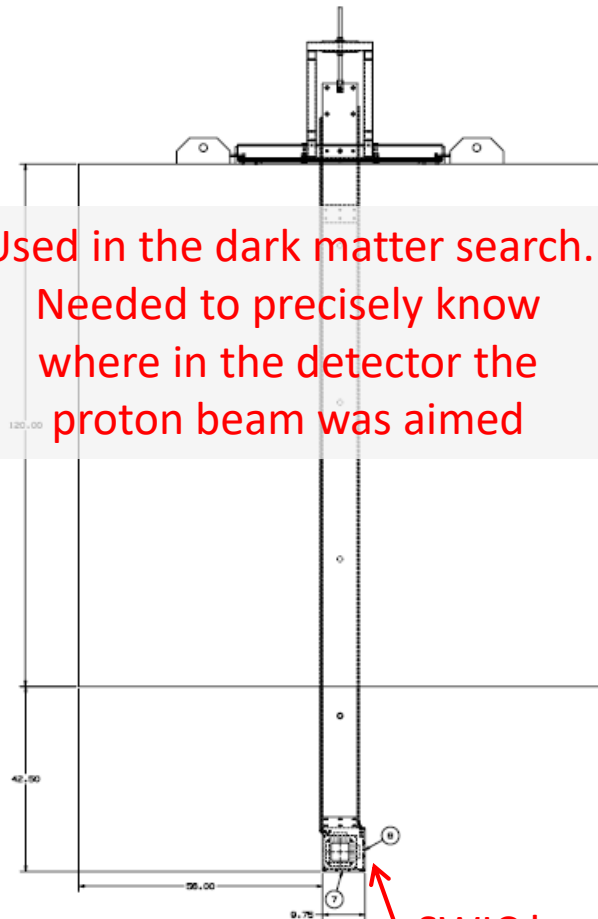
Access port is now a feature of BNB horns

Rewind to before Horn #2 failure

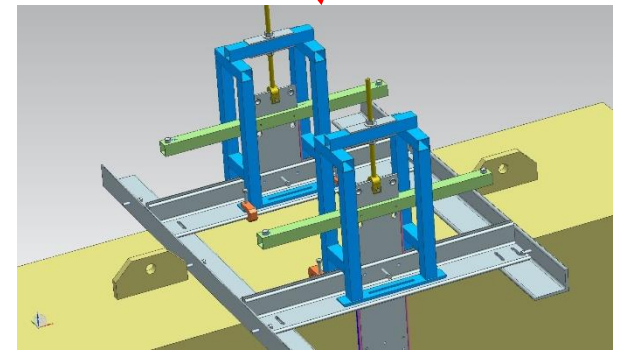
Temporary Profile Monitors at 25 m Absorber

Profile monitor wires are referenced to fiducials on top of hanger. Referencing can be done in the shop with entire hanger assembled.

Used in the dark matter search.
Needed to precisely know
where in the detector the
proton beam was aimed



Hanger sits on top of module.

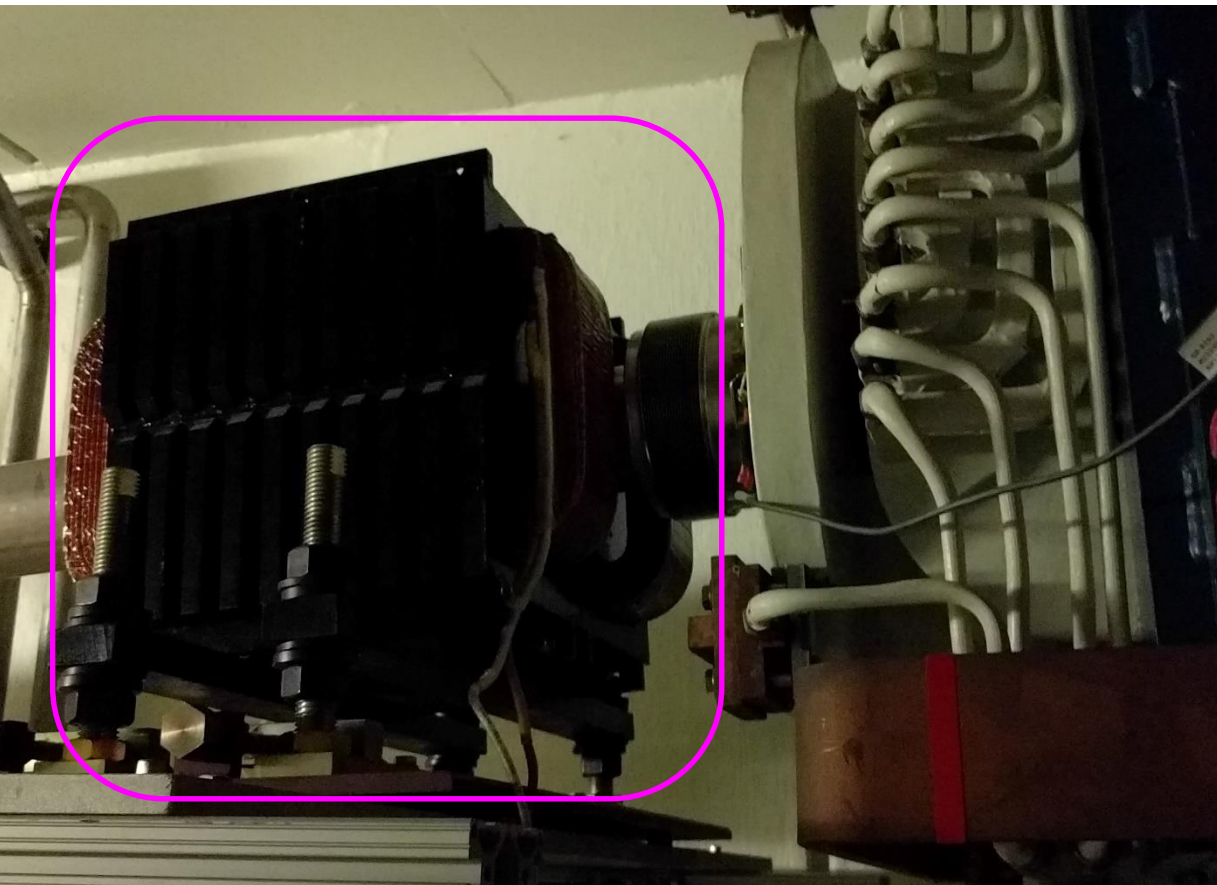
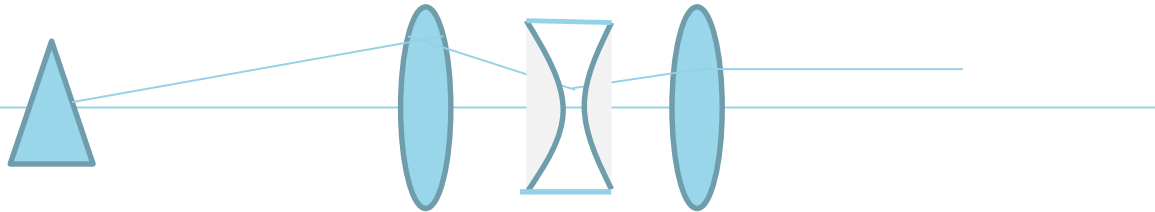


14	F1000603	PIN - 5/8 DIA.	2
13	F1000604	BUSHING - 5/8 DIA. X 15/16 LB.	2
12	F1000605	JAW	2
11	F1000606	LEFT COVER PLATE	2
10	F1000607	RIGHT COVER PLATE	2
9	F1000608	VERTICAL SPACER BAR	2
8	F1000609	HORIZONTAL SPACER BAR	2
7	F1000610	FLANGE	2
6	F1000611	FLANGE - SHORT	2
5	F1000612	CLAMP	2
4	F1000613	ANGLE 4 X 8 X 47	4
3	F1000614	ANGLE 4 X 8 X 72	2
2	F1000615	TOP FRAME WELDMENT	2
1	F1000616	DESCRIPTION	QTY.

JULIAN STANDARD SPECIFICATIONS		OWN	DATE	10-Aug-2014	Fermilab National Accelerator Laboratory UNITED STATES DEPARTMENT OF ENERGY
14	10	10	10	10	
DRAWN BY: J. KOBILARCIC		CHECKED BY: J. KOBILARCIC	MiniBOONE Absorber Multibeam Assembly		
SEE PARTS LIST		SCALE: 1/2" = 1'-0"		FIG. NO. E	F10026844
REV. 1		REV. 1		REV. 1	

Forward to Horn #3 running

Rapid Trim Magnet for Off-Target Running



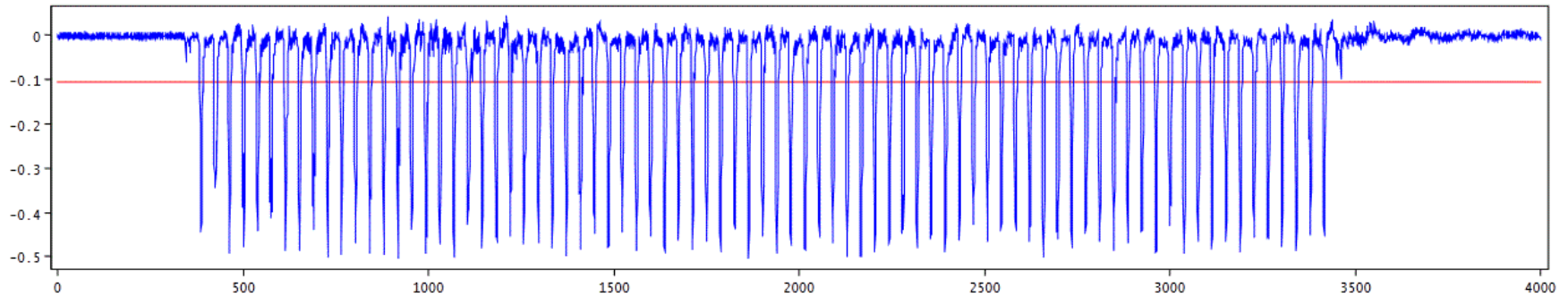
Installed at upstream focal point of final focusing triplet.

(Converts an angular kick to a parallel offset)

Able to ramp up and down in $< 1/30$ of a second (half a Booster cycle).

Can be triggered independently of horn – not rate limited by horn.

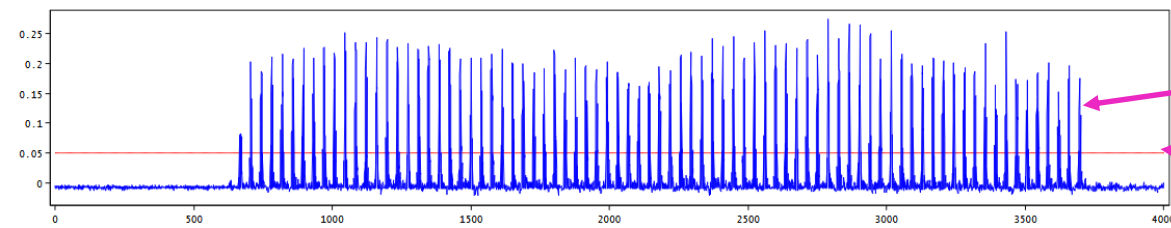
Resistive Wall Monitor Put to Use



2 GHz sample rate over entire spill.

Data is recorded every pulse, and is available through the Intensity Frontier Beam Database.

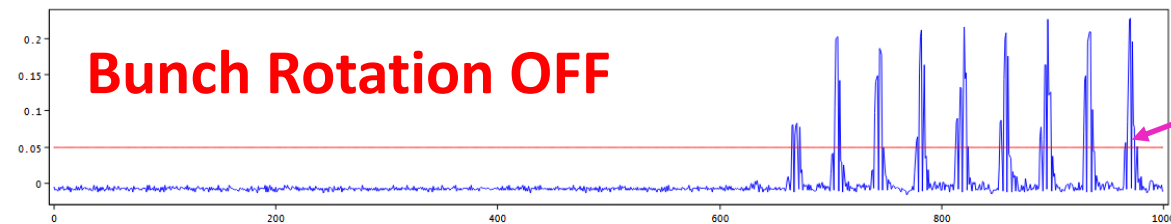




Individual bunches

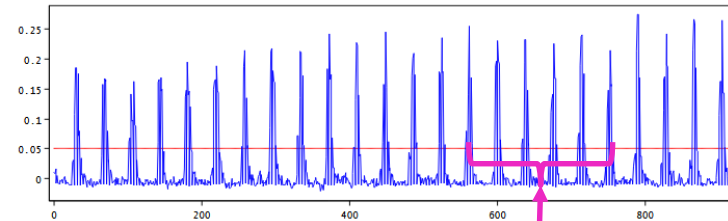
Trigger threshold

Bunch Rotation OFF



Problem with digitizer –
drops every fourth record

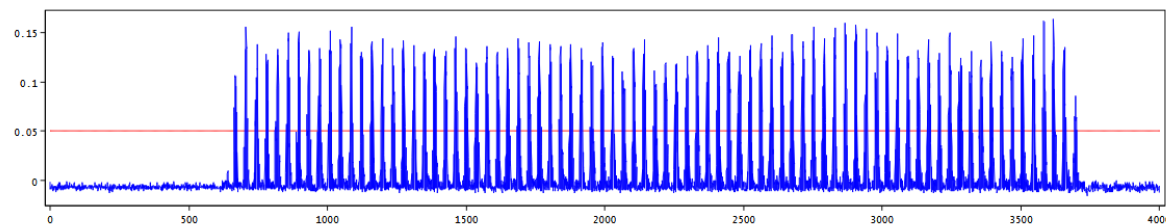
Digitizer measures
voltage induced by



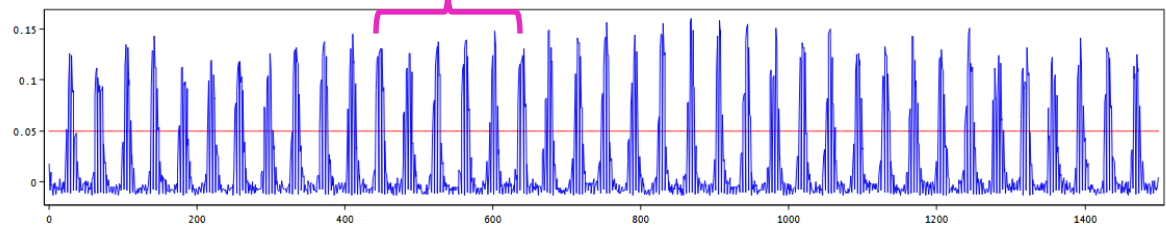
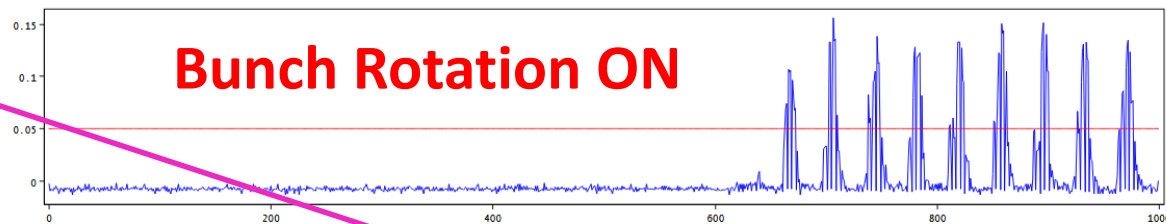
Spacing between bunches
remains the same

Beam looks “broader”

How much?

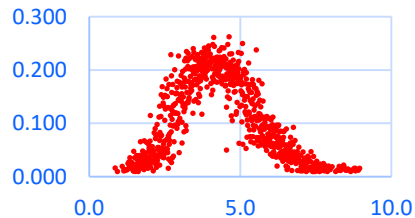


Bunch Rotation ON



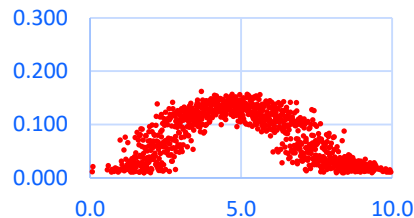
Bunch Rotation

Bunch Rotation OFF



(horizontal units: ns)

Bunch Rotation ON



(horizontal units: ns)

Based on 10 measurements each with bunch rotation on and off, bunch rotating the beam increases the 1-sigma time-spread at the resistive wall monitor from 1.48 ± 0.03 ns to 2.15 ± 0.13 ns.

Increase time spread, but decrease momentum spread.

Beam is smaller in high-dispersion regions → lower losses.

Under good conditions, the hourly rate could increase by ~7%.



SB-FD

MB Hall

LArTF

SB-ND

100m Hall

MI12S

Accelerator Signals

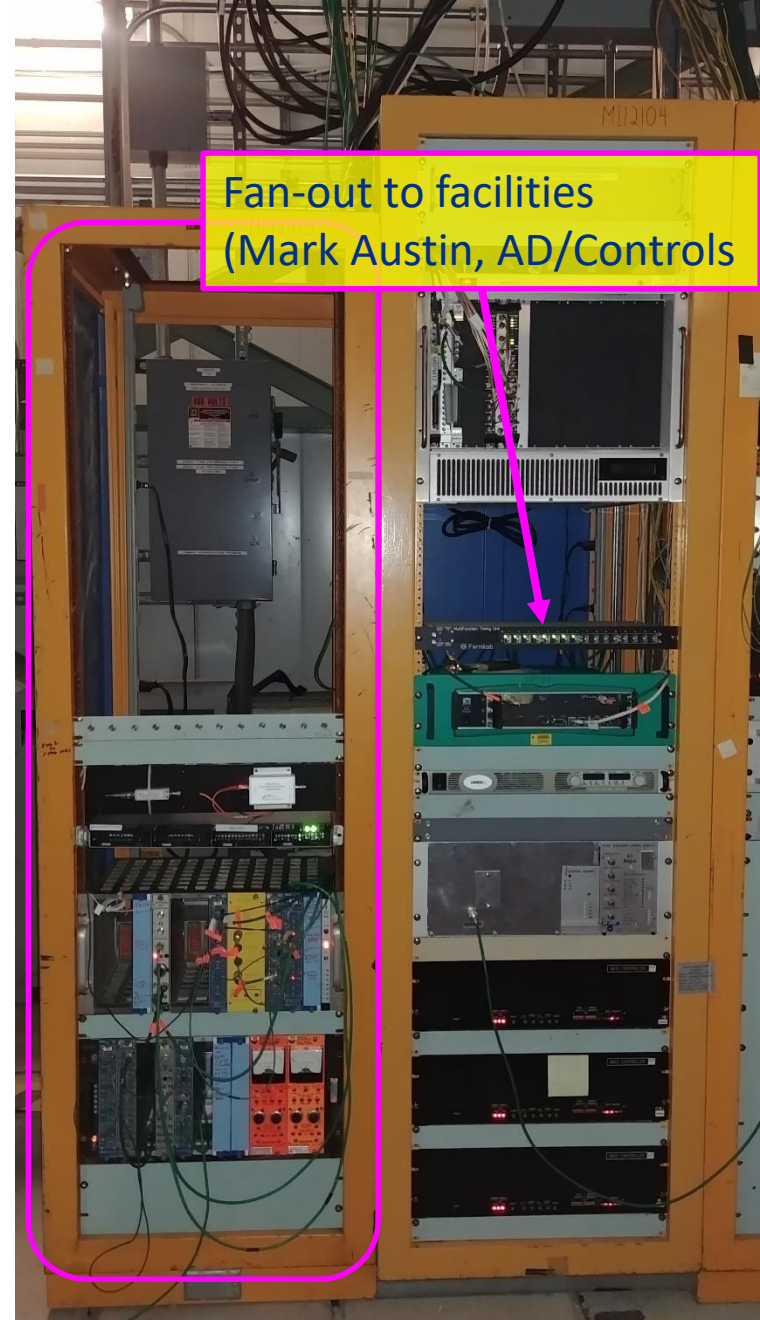
Many useful signals (Booster extraction, beam crossing RWM) are available in MI12S

Had been treating them as one-offs when sent to individual experiments

Coordinating with Neutrino Division to send standard signals to each facility. From that point, experiment can use as needed.

Dedicated rack in MI12S for experiments to use. Provides clean separation between AD and EXP hardware.

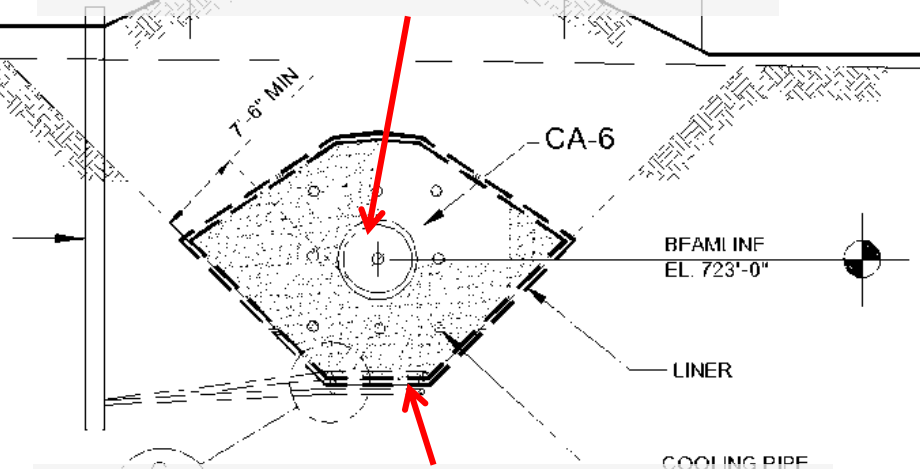
*Effort lead by Alyssa Miller,
AD/External Beams*



Fan-out to facilities
(Mark Austin, AD/Controls)

Ground Water Problems

Decay pipe buried in 12 to 15 feet of aggregate.



Aggregate is surrounded by two impermeable liners.

Early on we found a leak in the impermeable liners



Install high-density polyethylene cover to keep water away from liner.

This did not work, either



*Project lead by Cons Gattuso
AD/Engineering Support*

Backup Slides



Beamline -- Schematic

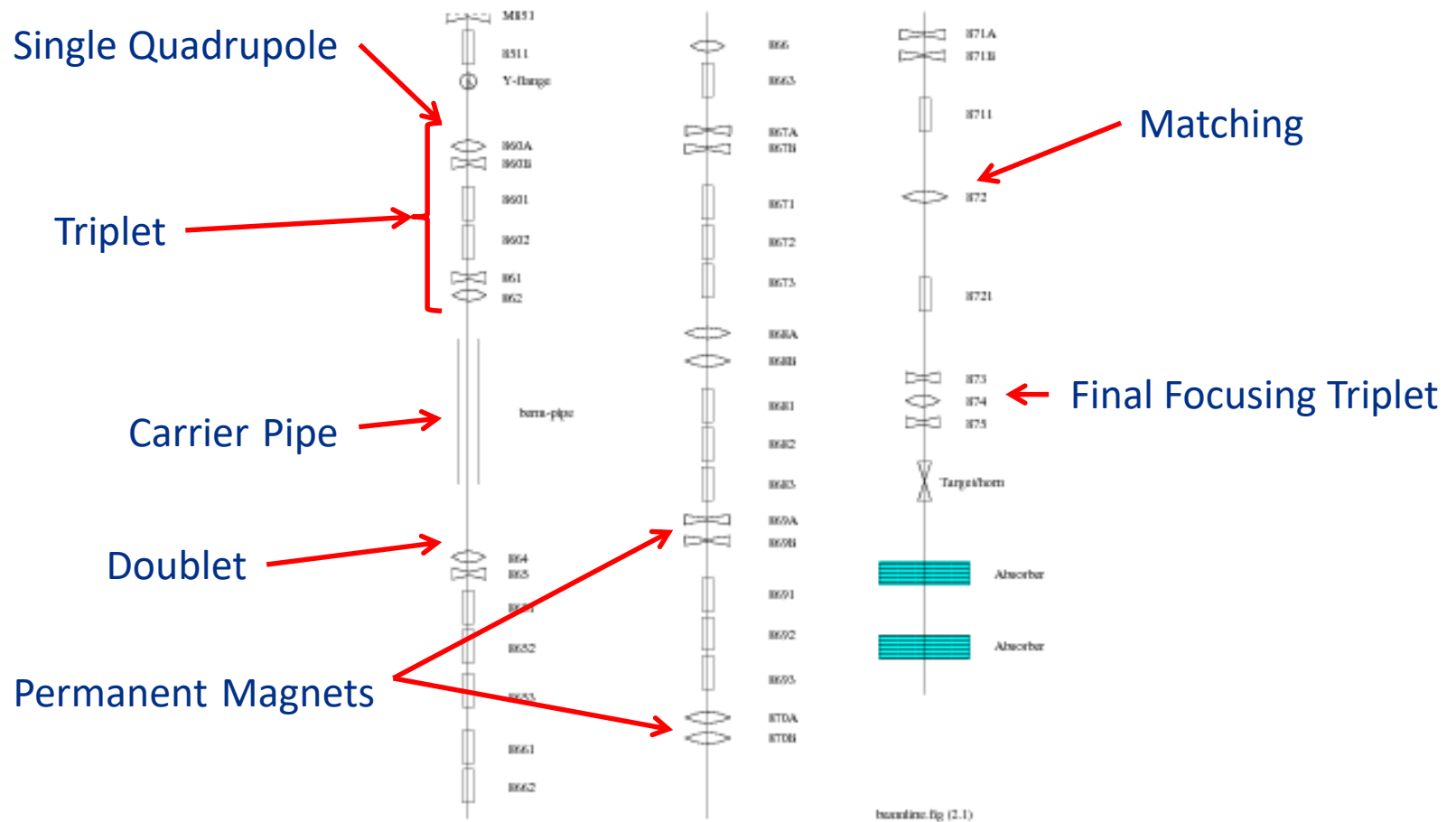


Figure 2.1: Beamline schematic and function. Elements are listed in Table 2.1.